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Book review

The Physics of Life: The Evolution of Everything, Adrian Bejan, St. Martin's Press (2016), 272 pages, ISBN: 978-1250078827.

This is an exceptionally interesting, beautiful and engaging book about the universal law of physics of evolution everywhere – the Constructal Law. Adrian Bejan explains why the new science of evolution is important to all of us. Along the way, he shows the physics origins of our most common and least questioned notions and urges, such as life span, freedom, knowledge, power, technology, hierarchy, purpose, economic sense, economies of scale, wealth, city, rule of law, diversity, and many more.

This new book has 11 chapters. In the opening chapter, Adrian Bejan has courage to answer the Nobel-Prize physicist Erwin Schrödinger's question "What is life?" He explains that life is movement that morphs freely toward easier movement, in all animate and inanimate flow systems.

In chapter 2, Bejan shows that all the flows of the living happen because they are driven by power. The power comes from all kinds of 'engines' (animal, geophysical, human made), which consume fuels (food, fossil, hydro, solar, wind, and many more). The movement dissipates the power, and the result is heat rejected to the surroundings. Overall, the physical effect of the consumption of fuel is the movement that occurs on the surface of the earth, i.e., the relentless mixing of the earth's crust.

In chapter 3, Bejan reports the linear relation between fuel spent (i.e., movement with purpose) and wealth (GDP), and shows that economics belongs in physics, along with biology, technology and social organization. All these evolutionary phenomena are possible because their flow systems are endowed with a physical property: freedom.

Chapter 4 is dedicated to technology evolution, as the most evident feature of the evolution of the human & machine species on the earth. He writes: "New technologies emerge so that they offer easier access to our flows— greater access to the space and resources available to us". For example, he uses the constructal law to account for the evolution of airplane designs over their 100-year history, and to predict the future of aerospace evolutionary design.

In chapter 5, Bejan uses sports evolution as a laboratory in which to observe biological evolution and animal locomotion. He explains how running and swimming are getting faster, and why body size is key. This predictive power also applies to team sports (basketball, baseball, soccer), and unites the sports with throwing motion: baseball, golf, hockey and boxing.

In chapter 6, Bejan uses city evolution in order to illustrate and predict social organization. Everything should evolve in ways to facilitate the flow of humans, for example, the city grid, the beltways, and the evacuation routes in cases of emergency.

Growth phenomena (chapter 7) are flows of spreading or collecting, which connect a point (source, sink) with a finite space

(area, volume). The history of the space covered by such flows is an S-shaped curve: the growth changes from slow to fast, and finally to slow again. Bejan shows how to predict the S curve, as a sequence of two ways to flow, a fast "invasion" by convection, followed by a slow "consolidation" by diffusion. The first regime accounts for the rising portion of the S curve, and the second for the slow-down. One S-curve example is the growth of the ice volume of the snowflake, or more broadly the phenomenon of "rapid" solidification.

In chapter 8, Bejan explores the manifestations of the constructal law in new areas of social organization such as politics, science, government and societal change. One example is the growth of the readership of one scientific publication. Another is the rise and fall in the popularity of a politician or an idea. This phenomenon is so common that it has generated entire fields of research that seem unrelated: the spreading of biological populations, cancer tumors, chemical reactions, contaminants, languages, news, information, innovations, technologies, infrastructure, and economic activity.

In chapter 9, Bejan argues that knowledge is the name for two design aspects that are present simultaneously: the idea of the design change that should be made, and the action (the implementation of the design change). He argues convincingly that information and data are not knowledge.

Life span (death) is the subject of chapter 10. Bejan shows that the bigger movers should live longer and travel farther during life. He illustrates this evolutionary design phenomenon with specific examples, animate and inanimate: rivers, atmospheric currents, animals, vehicles, rolling stones, and eddies of turbulence.

The last chapter of the book is the punch line: life and evolution are physics. They are not the specialty of a narrow and descriptive domain such as biology, or technology. Bejan reviews the 20-year record of the constructal law, and how this law of physics is embraced and applied by many other scientists.

This book is an invitation to think and to have fun with ideas. Adrian Bejan concludes that the constructal law "is bound to evolve, to serve our thinking better". My own conclusion is that readers of this book are able to see the world more clearly, and to predict its future better and with greater confidence.

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